

CHAPTER 13: LEARNING ANALYTICS AND THEIR APPLICATION IN TECHNOLOGY-ENHANCED PROFESSIONAL LEARNING

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Learning analytics (LA) is the "measurement, collection, analysis and reporting of data about learners and their contexts, for purposes of understanding and optimising learning and the environments in which it occurs" (Siemens & Gasevic, 2012). Originally, “analytic” refers to a way of using data to support decision-making and understanding a domain. Essential LA components are (1) data, (2) goals or (research) questions, optionally based on educational theory, (3) measures that give information about goal attainment or (research) construct, optionally (4) descriptive or predictive models that use these values as variables, and (5) computing models and routines that compute these measures’ values, modelling results from the given data. LA systems also comprise (6) automatic or semi-automatic ways of reporting these results to the chosen stakeholders. Optionally, (7) the results can be deployed within some application functionality. Examples of 1) and 3) are ‘clickstream’ dataⁱ used to measure learner behaviour and knowledge, or text data underpinning domain models. The goal (2) could be to depict collaboration between learners. The descriptive or predictive models (4) may comprise learner profiles or models for predicting whether a learner is ‘at risk of dropping out’. The computing models that determine these measures (5) range from simple counts via clustering techniques to classifier learning.ⁱⁱ The models may be purely statistical (correlating measured variables) or refer to theory (which would, for example, explain why someone with certain behaviour is at risk of dropping out, and what the behaviour and the

risk have to do with learning). A typical choice for (6) is dashboards, when the results are reported to teachers or information is given as feedback to learners. An example of (7) is the use of learner models to offer users personalised learning resources that are assumed useful for an individual's learning. For a related model of components, see (Greller & Drachsler, 2012).

Learning analytics is developed within various disciplinary communities and is an instantiation of different ideas, each with its own long tradition. "Business analytics on e-learning" is one such perspective; another one is "Web analytics on e-learning". Other traditions are those of "learning analytics", "knowledge analytics" and "academic analytics" developed in the field of Knowledge Management (see Siadaty et al., 2012 for a use of traditional Knowledge Management concepts in LA for workplace learning). A common theme in these fields is the detailed analysis of behavioural data describing the usage and production of knowledge resources. LA is also closely related to *educational data mining* (EDM). Both analyze learning data: EDM focuses on the data-mining models and fully-automated modelling and personalisation, whereas LA draws on models from different disciplines. LA also applies modelling as well as personalizing in a more semi-automated and interactive fashion (Siemens & Baker, 2012). Lastly, interactive LA, that is designed to be used by learners and others who are directly involved in the learning, are instances of *feedback and awareness systems* (Berendt et al., 2012): systems that give a user feedback about her/his own behaviour, in an attempt to raise awareness about issues such as how one learns or how one learns in relation to what one thinks about how one learns.

Learning analytics could be valuable in workplaces that focus on effectiveness and operational excellence (van Barneveld, Arnold, & Campbell, 2012). In this chapter, we

investigate this claim in more detail, highlighting both the potential and issues of applying LA in technology-enhanced professional learning. In the remainder of this section, we offer a brief overview of important themes in LA research and practice. Then, in Section 2, a case study illustrates the use of LA within a pan-European platform for teachers' professional development. Section 3 highlights challenges, and Section 4 concludes with an outlook on key issues in the use of LA in supporting professional learning.

The field of LA is motivated to a large degree by the recent growth in the use of Learning Management Systems and other online environments, and the wealth of data they produce. In such environments, learners use digital tools and leave digital traces. There is a sense that these traces can be used to make learning more effective, yet it is not always clear how the data can best be used. Additionally, there is the growing pressure on academic education institutions for accountability through performance measurement (Ferguson, 2012). In this sense, the unique features that LA strive for is to be learner-centric and informed by pedagogical theory (Ferguson, 2012). LA are also often interactive and visual in their reporting of results, in particular when learners are the recipients of the data, cf. (Bienkowski, Feng, & Means, 2012; Santos, Govaerts, Verbert, & Duval, 2012). The focus on 'interactivity' stems from the goal of supporting reflection (McAuley, O'Connor, & Lewis, 2012), metacognition, and thereby self-regulation, as key drivers of professional learning (Littlejohn, Milligan, & Margaryan, 2012; Siadat Jovanović, & Gašević, this volume). Analytics may comprise data on learning activities, such as the number of posts made in a forum, comparisons of these to average levels in a relevant community, and interpretations of these activities in terms of goals or categories, for example, reasoning, evaluation, extension and challenges (Ferguson & Buckingham Shum, 2012).

In today's networked environments, learning rarely happens in isolation (Sloep, this volume). *Social Learning Analytics (SLA)* draws on the idea "that new skills and ideas are not solely individual achievements, but are developed, carried forward, and passed on through interaction and collaboration [...] Understanding learning in these settings requires us to pay attention to group processes of knowledge construction – how groups of people learn together using tools in different settings. The focus must be not only on learners, but also on their tools and contexts" (Ferguson & Buckingham Shum, 2012). When SLA are used, the unit of analysis - and the potential consequences - differ. For example, a learning group with members who are at risk of dropping out should receive help *as a group* (rather than only support for the individual members). This solution can encourage a mutual awareness of problems and a shared approach to support that overrides opinions about individuals' failure or the abandonment of responsibility towards others.

In formal learning settings, such as professional training or academic education, learning analytics most often focus at the level of a 'course' or another administrative structure (Ferguson, 2012). Whereas in informal learning settings, LA focus at the level of groups and networks of learning (ibid). In informal learning settings, where there is usually no set syllabus, course structure, and accreditation, learning interactions are not usually guided by teacher-learner relationships. One example of an informal, professional learning setting is a 'learning network'. Learning networks are technology-supported communities, in which learners share and develop knowledge (Sloep & Berlanga, 2011). Studies of the benefits of such networks for professional development (OECD, 2009; Suthers, Dwyer, Medina, & Vatrappu, 2010; Berlanga & Vuorikari, 2012) highlighted a need for tools and methods that could help find "reliable evidence of how, when and why online social networks do, and do not, advance learning" (Schlager, Farooq, Fusco, Schank, & Dwyer, 2009). Examples of LA

methods and processes that could be applied in informal learning setting have been proposed (Song, Petrushyna, Cao, & Klamma, 2011; Cambridge & Perez-Lopez, 2012; Vuorikari & Scimeca, 2013).

We present one such example, from a technology-supported teacher network called eTwinningⁱⁱⁱ. With more than 190,000 members, eTwinning is a European network of schools. Participating teachers collaborate online while learning new skills. We first introduce the context for the case study – the need for teachers’ professional development, before we present the concept of eTwinning Analytics to exemplify the use of SLA in a professional context.

Case study: eTwinning analytics

Nowadays, there is a need to upskill K-12 teachers to help them respond to rapidly changing needs in society. Teachers, however, feel that they do not have sufficient opportunities for professional development (OECD, 2009). Today, the most common form of ICT-related professional development undertaken by teachers is “personal learning on ICT in their own time” (Wastiau et al., 2013). Only one out of three students in Europe are taught by teachers who have participated in compulsory ICT training (Wastiau et al., 2013). Co-operation amongst teachers can create opportunities for exchange of ideas and practical advice, enhancing professionalism, increasing feelings of self-efficacy and preventing stress and “burnout” (OECD, 2009).

Teacher networks have started to emerge, with early examples including Tapped-in^{iv} and Teachernet^v. These aim to improve both the *quality of the teaching profession* and the

learning experience of students, by encouraging collaboration and knowledge exchange at both teacher and student level (Vuorikari et al., 2012). Such networks allow teachers to upskill and to gain new competences in the context of daily work. However these networks rely on professionals' voluntary participation.

eTwinning is one such network. The eTwinning platform offers teachers three main streams of activities: (1) school collaboration projects, where teachers can find partner schools to run cross-border activities using ICT; (2) various formal and informal professional development (PD) opportunities, including online courses and special interest groups; and (3) social networking. eTwinning needed longitudinal studies to monitor and measure various forms of teacher co-operation, a need that led to the development of eTwinning analytics. eTwinning analytics is “the measurement, collection, analysis and reporting of data about eTwinners and their contexts, for the purposes of understanding and optimising their co-operation and the environment in which it occurs” (Vuorikari & Scimeca, 2013). eTwinning Analytics fall into the category of Social Analytics, where the interest is in teachers' co-operation behaviours and patterns over a long-term period (5 years) and how these patterns and behaviours can support teachers' continuous professional development, when knowledge building takes place in a cultural, social and technology-enhanced setting.

The components of the eTwinning Analytics are as follows: (1) Data are gathered from the eTwinning platform. (2) The goal is to operationalise the construct of teachers' co-operation in eTwinning - or in other words, to find quantitative measures of what it means for teachers to cooperate and what it means when one individual cooperates more than another (3). Measures include teachers' actions using various digital tools, as well as their cooperative interactions with each other. These cooperation activities are mapped using OECD indices,

namely that of a) teachers' *exchange and co-ordination activities*, for example the exchange of learning materials and ideas, and b) *professional collaboration activities*, such as cross-border school collaboration. In the following example, we demonstrate the use of eTwinning Analytics to explore three research questions (RQ). An extended version of this study can be found in (Vuorikari & Scimeca, 2013).

RQ1: eTwinning retention rate: Is there evidence of teachers remaining engaged with eTwinning over a long period of time (i.e. since its start in 2005)?

“Retention rate” is a Web-analytics measure used in online marketing. It is the percentage of users who sign up for the service and come back within a period of time. The retention rate for eTwinning refers to the percentage of teachers who have registered on the platform since its inception in 2005, and who still return to log-in annually. Figure 13.1 shows the eTwinning retention in 2011 and in 2012. The x-axis represents the number of years since registration on eTwinning, and the vertical axis represents the percentage of teachers. “0 years” refers to people who registered in 2011, “1 years” to people who registered in 2010, etc.

[PLACE FIGURE 13.1 HERE]

We can observe that in year 0, the retention rate is high. For example, 89% of users who registered on eTwinning in 2011 and 86% who registered in 2012 returned to login into the platform at least once during that year. A year after the registration, we can observe a steep decline: about 40% of users still login onto the eTwinning. This trend remains much the same from 2011 to 2012. Finally, about 1 in 6 of teachers registered 5 to 7 years ago still remain engaged. Therefore, it seems that eTwinning has the potential to engage users over a long

time-period. More research is needed to understand why so many teachers drop out in Year 1 only after a short involvement. What challenges did they face? Were these related to the collaborative nature of their activities on the platform? Is the drop-out related to problems with the platform, or did the network not help teachers sufficiently with their professional learning needs?

RQ2: Teachers' co-operation activities: Are there any trends that emerge in teachers' co-operation activities over a long period of time?

Figure 13.2 shows the extent to which teachers have engaged in various co-operation activities, including participation in cross-border school collaboration and social networking activities, such as adding Contacts and/or participating in Teachers' rooms. 'Contacts' are explicit links to other users as in social-networking sites, and 'Teachers' rooms' are interactive spaces dedicated to various subjects such as "Les langues romanes", a French-speaking room on Romanic languages. The number of years since registration are counted backwards from 2011 as above in Figure 13.1, and the percentages illustrate a data snapshot taken in February 2012.

[PLACE FIGURE 13.2 HERE]

Two patterns can be observed. Firstly, in terms of collaboration, it appears that in the early years of registration on the platform users are less engaged (average 18%) in joint project work compared to those who have been on the platform for more than 2 years (average 30%). Secondly, in terms of social networking, teachers in their early years of participation in the platform (registered in year 0 and 1) are slightly more involved in the Teachers' rooms than those who have been using the platform for longer. Similarly, the Contacts feature is used by

almost half of the teachers in their first year of registration (45%), and use seems to intensify after that starting period.

Observing longitudinal patterns is important in helping us understand how a digital platform such as eTwinning can serve teachers' professional learning needs over the length of their career. To experience a full range of professional development activities in eTwinning, and to gain full advantage of the participation in a teacher network, teachers need to make a substantial time investment. The analytics show that teachers in their early years of participation in the platform are less engaged in co-operation activities, a finding that prompts further questions of how the platform can support them better. The monitoring of teachers' professional development paths through eTwinning Analytics is outlined in Cao, Klamma, Pham, & Vuorikari (2012).

RQ3: Use of social networking tools: Do teachers who engage in professional collaboration on the platform and those who do not use social networking tools in the same way?

[PLACE FIGURE 13.3 HERE]

Figure 13.3 illustrates the usage of four different social networking tools (Contact, Profile picture, Journal Wall posts and Teachers' rooms) by those who engage in cross-school project work and those who don't. The Contacts and Teachers' rooms functionalities have been described above. Profile pictures are pictures, usually photographs, uploaded by the users to describe themselves. Journal Wall posts are short descriptions of current activities, also uploaded by the user. The percentages shown describe the same data snapshot taken in February 2012 as used for Figure 13. 2.

Social networking tools appear to be used more by teachers who are involved in project collaboration (average 64%) than those who are not (36%). An exception is the Contacts tool, which is used by a similar proportion of those who do and those who do not engage in the project, collaborating within the platform. However, the Analytics, as such, do not shed any light on why this is the case.

About 2 out of 3 users of social networking tools on the eTwinning platform were also active in project collaboration. The results illustrate that teachers use a large variety of tools and engage in many activities through the platform. However, eTwinning Analytics cannot give insight into the cause and effects of tools usage and professional collaboration. Questions remain about professionals' interactions with various tools. We are interested in understanding, for example, whether the use of social networking tools can lead to better project collaboration opportunities. However, one limitation is the difficulty in measuring indicators of communication taking place outside the platform. These limitations pose challenges for gaining a good, overall picture of the interactions and learning contexts within tools such as the eTwinning network. In the conclusions section in this chapter, we will sketch some possible ways to overcome these limitations.

The teachers who are not involved in project collaboration via the platform are nevertheless building weak ties through social networking (such as, sourcing and adding other teachers as professional contacts). Weak ties play an important role in the enhancement of information flow in networks, leading to emergence of new ideas (Haythornthwaite, 2001). Previous studies on eTwinning networks have evidenced that both Project and Contact networks are dense and well-connected, illustrated by the number of edges, average path length, diameter,

the number of components, and other measures of connectedness properties in these networks (Pham, Cao, Petrushyna, & Klamma, 2012).

Challenges

In the previous section, we demonstrated a ‘proof of concept’ of SLA to support learning within an informal, professional network for teachers. Instead of focusing on each individual learner, the goal was to use aggregate statistics to view emerging, long-term trends. In general, the use of descriptive statistics does not allow us to distinguish between cause and effect. However, the results allow the development of new hypotheses for further investigation. More sophisticated and combinatorial analysis of data will lead to a deeper understanding of when informal learning networks better support teachers’ personal and professional development goals. For example, mixed method analysis (using exploratory and confirmatory methods and/or qualitative and quantitative data) is required to further investigate relevant questions (for example those around the relationships between social networking tools and project collaboration). These methods may involve gathering opinions from all stakeholders, especially from the teachers who use eTwinning for their professional learning.^{vi}

In the context of professional learning, when investigating the value of LA for learners and their employers, we cannot make simple delimitations that equate types of systems with users and stakeholders and a given power relation. For example, an LA system that displays aggregates over learner behaviour in a Web analytics / business analytics way may primarily address site-operator users. However, these may act fully on behalf of the learners, the analytics system may have been co-designed with the help of learners, and the learners may

also profit as users when they see how the learning environment to which they contribute by their activities evolves over time. Conversely, an LA system that displays a range of personalized metacognition-supporting analytics may primarily target management users. The end users (learners) may not have had a say in the choice of the system, and it may prove to be most used by and useful for learners' managers, for evaluating employee performance. Therefore, ascertaining the potential of a system in supporting learning is not straightforward.

The case study illustrates that a great deal of professional learning occurs outside formal curricula, which concurs with many of the other studies of professional work and learning in this book. Professional learning can be self-organised and self-regulated, is not standardised and differs between learners and learner groups. The requirements for LA in these sorts of settings are highly context-dependent. The specific context (for example in professional learning) determines the target variables and success measures for goal attainment, which can vary from a group to one learner to another within the same cohort of learners. Given the multitude of users, stakeholders, use cases, and topics, there are important questions around who decides on the design, choice, and use of learning analytics for technology-enhanced professional learning.

One such question is the extent to which the use of LA is optional or mandatory. While LA may today seem like an additional, optional and 'fun' tool, this optionality is likely to change with the increasing maturation and professionalisation of the LA field, with LA becoming an integral component of "learning environments". Just as Web sites use instruments for measuring 'click-throughs' (a standardised measure) to earn money from the number of people who have viewed the site, LAs will likely be standardised and made non-optional in future learning environments. Selection of measures to use then may no longer be the choice

of the site operator. This development will exert pressure on these operators and/or teachers who work with the site to “teach to the test” – to design materials that will lead learners to exhibit the “right” behaviour.^{vii} Likewise, learners may be asked to submit their “LA portfolios” in addition to or instead of other measures of learning outcomes, and therefore begin to “learn to the test (that is, the LA)”. This vision appears not too far-fetched in view of the number of participants registering for Massive Online Open Courses (MOOCs) (Siemens, 2012), for which assessment of learning outcomes remains a major factor limiting growth. For example, Coursera^{viii}, a company partnering with universities in offering MOOCs, is considering selling learner/learning data to potential future employers (Young, 2012). This vision of LA does not align well with the highly personalised and fluid nature of professional work and learning laid out in the chapters in sections 1 and 2 of this book.

Lastly, many LAs have built-in feedback and awareness systems that could support learners’ self-regulation activities. Designers of LA systems and interfaces should build on what is known from the literature about how feedback can be used to enhance professional learning (Hattie & Timperley, 2007; Boshuzien & van der Weil, this volume; Siadaty et al., this volume). In user evaluations, system designers should monitor whether learners know when and how to use feedback to support their learning tasks.

Outlook

In the future, it is critical to involve learners in decisions around LA: what goals to pursue when supporting professional learning; whether to use LA and which ones; what data to record and analyse; which interaction choices to use; which measures to compute and how to evaluate; and how to ensure that LA do not contribute to information overload. The

development of LAs that support learning requires these specific questions to be raised and discussed, in a participatory requirements analysis and system development process. In other words, ideally all stakeholders of LA should be actively involved in the design process in order to help ensure the LA system designed meets their needs and is [usable](#).^{ix} We believe that such participation is the key to opening up the potential of LA for professional learning – and other forms of learning. First, an understanding of the interests and concerns of different stakeholders may be used to improve the design of the platform by website and platform operators (or, in general, the providers and managers of the learning / LA environment). Second, it would also be interesting to allow users of the platform to reflect and comment on the results of design and use, stimulating further-reaching improvements.

One example of user feedback being utilised to improve systems design can be seen in relation to privacy, as a constraint on – or future feature of – LAs. LAs can be viewed as a form of ‘surveillance’ technology. Questions that relate to surveillance technologies should be discussed with all stakeholders affected by the technology. Critical questions include: do the benefits of the technology systems (for example, enhanced learning) offset the disadvantages (for example, choices and behaviours being tracked)? Does the surveillance have effects in and of itself (for example, are there inhibiting factors, such as the knowledge of being observed continuously leading to restrained dialogue on the part of the user)? What are the effects of a learner’s /teacher’s/ manager’s actions on others while these actions are under surveillance? How are the interests of various people weighted and reconciled? (Gürses, 2010). The LA community is aware of these privacy issues (see, for example, Campbell, DeBlois, & Oblinger, 2007; Greller & Drachsler, 2012). Yet the community operates on the basis of an oversimplified assumption that privacy can be safeguarded by anonymising or access-controlling specific types of personal data (see Berendt, 2012, for an

extended discussion). This view extends widely beyond the LA domain. In work contexts, two additional factors are important: first, employers must respect legal restrictions on employee surveillance, and second, for both employers and employees, the personal and financial consequences of a breach of trust in employment relations are, in most cases, likely to be more significant than those in learning relationships of instructor-learner, teacher-pupil, or company-customers.^x

In general, LA's greatest potential in supporting informal, social professional learning lies in tools that learners themselves interact with. Social Semantic Web (SSW) tools, such as those described by Siadaty et al. (this volume), are particularly interesting. These tools take into account the diversity of real-world online tools that people use, particularly in informal learning settings. LA could be an interesting "piggyback" addition alongside these sorts of tools, and their addition appears feasible given that the heterogeneous data are already recorded and semantically analysed and transformed by the Semantic Technologies used for SSW tools. Siadaty et al. (this volume) offer a glimpse of the possibilities afforded by LA when used in tandem with SSW tools. A glimpse of the possibilities of LA additions to SSW tools is offered by the divergence between professional learners' self-reported attitudes and behaviour reported by Siadaty et al. (this volume): Learners, when describing themselves, usually stated that the organizational context influenced their setting of their learning goals. However, the data gathered during their learning activities showed that they relied just as much on their social context for setting their learning goals. An analysis of the self-report data and the behavioural data can surface these sorts of mis-alignments. Reflecting these sorts of discrepancies to learners could help them reflect on their self-regulated professional learning, leading them to new, productive insights.

Another direction for future research that brings together opportunities and challenges described in this paper is the use of LA in blended learning. The case study illustrates that learning rarely takes place within a single environment. Combinations of different learning environments – both digital and physical – are likely to increasingly become complex in continuing professional learning. A question arises as to what extent LA could – and should – span more (or even all) these environments, whether ‘online’ or in ‘off-line’, physical settings. Technically, research in this domain could draw on methods from Web analytics and Web mining to collect and analyse data from different communication and distribution ‘channels’ between businesses and customers (Teltzrow & Berendt, 2003). While this could yield interesting insights into the use of online versus face-to-face activities (Brian McNely, Gestwicki, Holden Hill, Parli-Horne, & Johnson, 2012), the extended data collection may require too much surveillance and could cause privacy problems. Therefore, new methods for empowering users to take part in or opt out of analytics, and to make informed choices around analytics, will become critical. The field of LA has a unique opportunity to mature by embracing these novel and difficult challenges through participatory design that truly reflects the concerns of all the different stakeholders affected.

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Notes

ⁱ Records of requested materials (such as clicked-on Web pages) and user input (such as queries or other typed-in data)

ⁱⁱ Classifiers are models in machine learning. They include rules for classifying or predicting whether an individual belongs to a certain class. For example, a classifier might predict that someone with certain traits and behaviour is likely to obtain high scores in a test, or is likely to not finish a certain activity.

ⁱⁱⁱ <http://www.etwinning.net>

^{iv} <http://tappedin.org>

^v webarchive.nationalarchives.gov.uk/*/http://www.teachernet.gov.uk/

^{vi} Other stakeholders include the site providers, school managements, school authorities, pupils, parents, ... Depending on the specific questions and value decisions, the voices of stakeholder groups will be heard and/or will influence interpretations and design decisions. We cannot cover all these decisions in detail here, but want to focus on the teachers as stakeholders.

^{vii} Greller and Drachsler (2012) go beyond this by claiming that „the real dangers [are] that the extended and organized collection of learner data may not so much bring added benefits to the individual, but instead [provide] a tool for HEIs, companies, or governments to increase manipulative control over students, employees, and citizens, thereby abusing LA as a means to reinforce segregation, peer pressure and conformism rather than to help construct a needs-driven learning society.” (p. 54).

^{viii} <http://www.coursera.org>

^{ix} Agile development methodologies such as those proposed by Clow (this volume) may be a solution..

^x See <http://epic.org/privacy/workplace/> for an extensive resource collection.

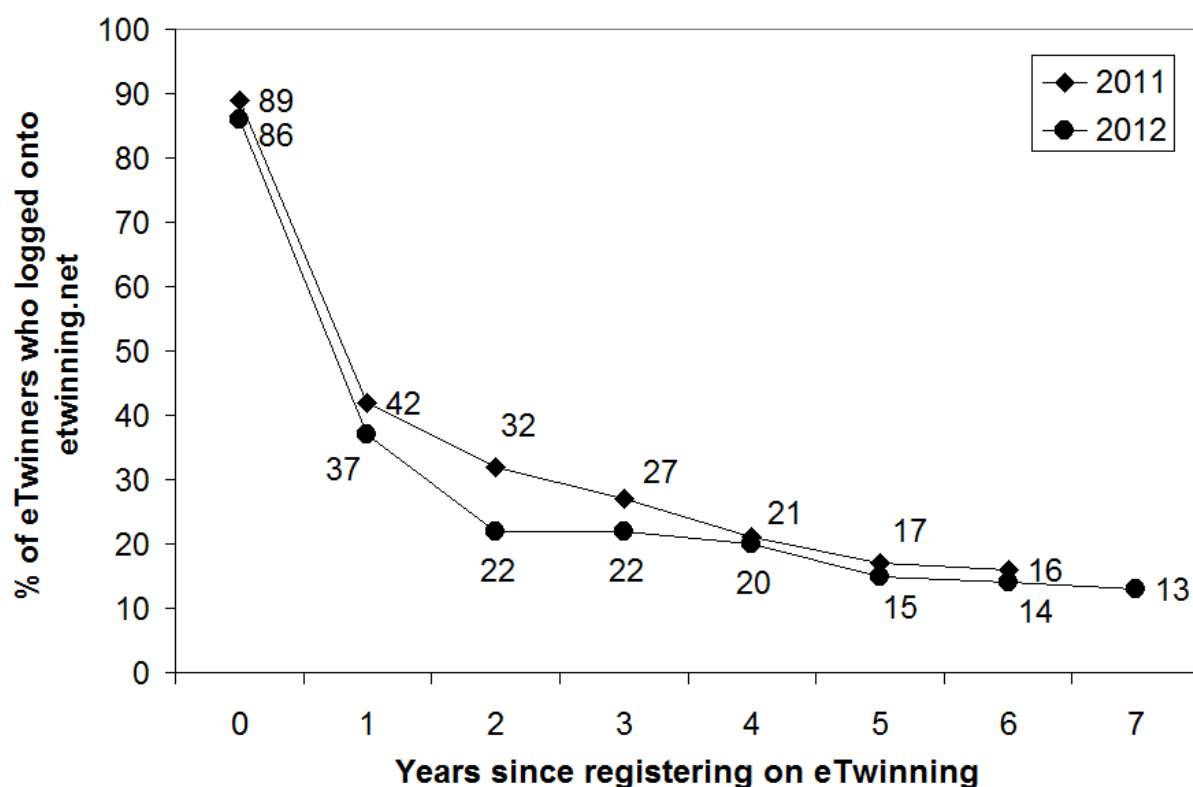


Fig. 13.1. eTwinning retention rate in 2011. Data on returning eTwinners by the year of their registration: “0 year” refers to eTwinners who registered in 2011; “1 year” = in 2010, etc.

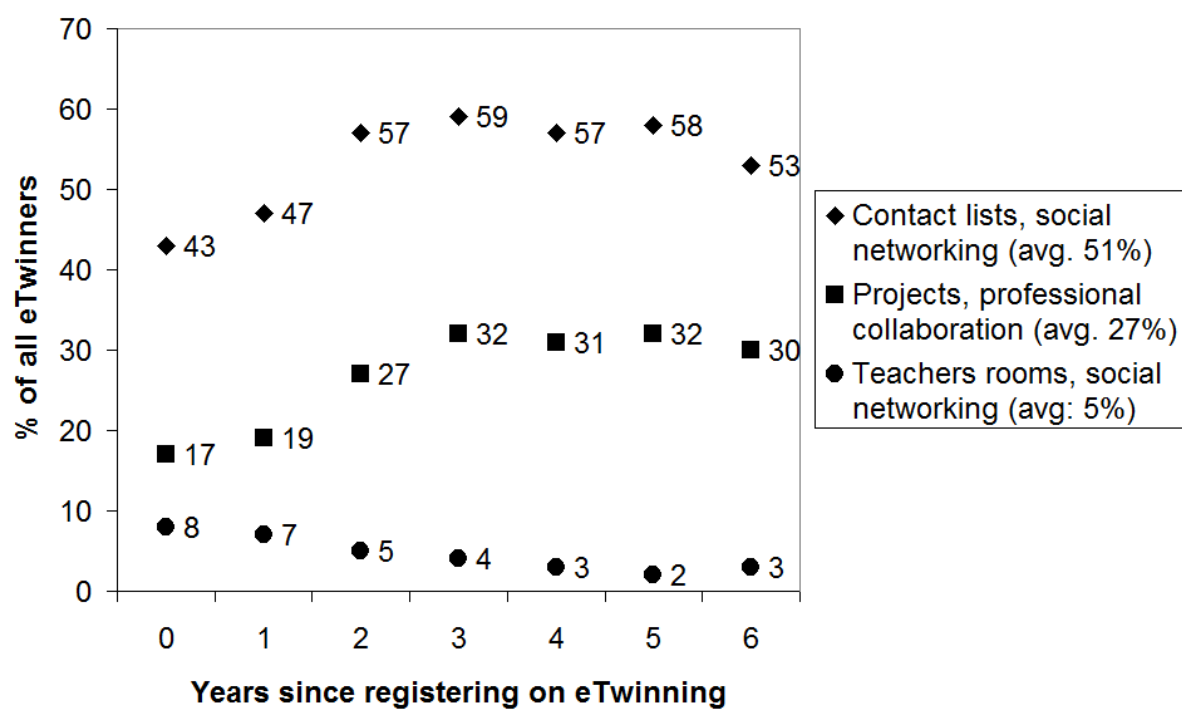


Fig. 13.2. eTwinners engagement on the portal disaggregated by the year of registration. “0 year” refers to eTwinners who registered in 2011; “1 year” to those registered in 2010, etc.

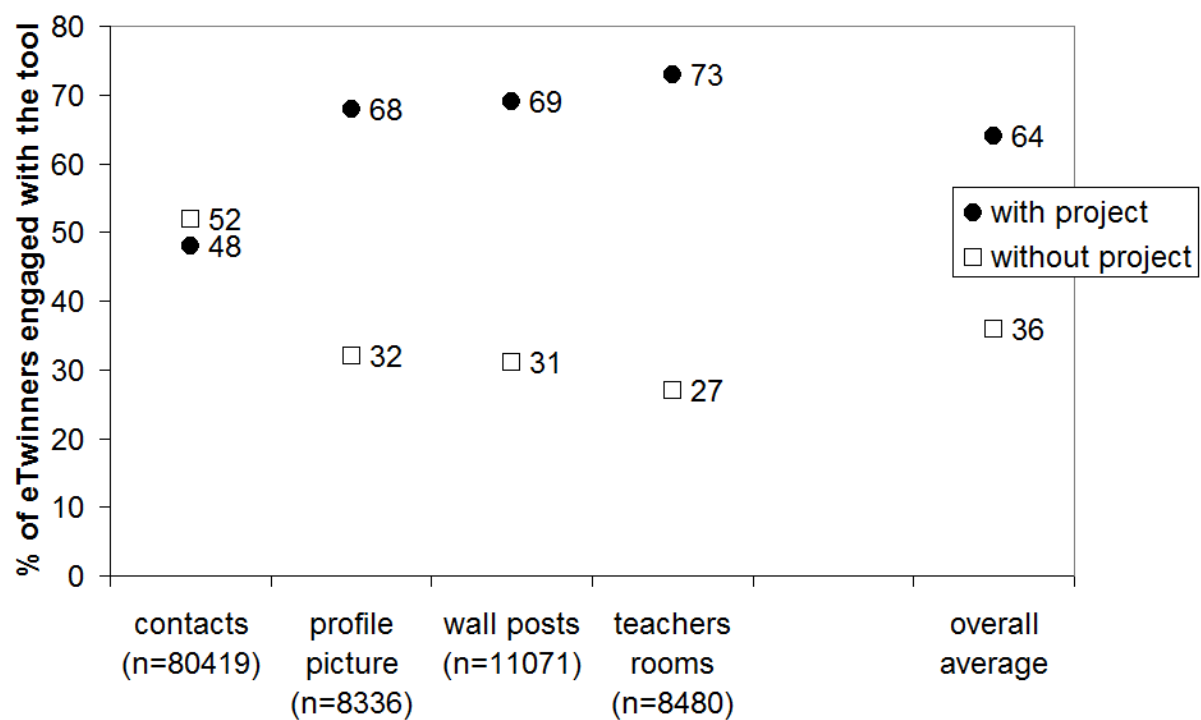


Fig. 13.3. eTwinners' use of social networking tools, divided by eTwinners with projects and without. Snapshot of data extracted from SteerCom-Desktop tool (Feb 2012).